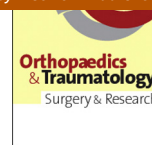




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Original article

A comparison of proximal femoral locking compression plates with dynamic hip screws in extracapsular femoral fractures



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ABSTRACT

Introduction: The potential value of proximal femoral locking compression plate (PFLCP) for extracapsular femoral fractures has been discussed in several case reports; however, clinical control studies are lacking. Therefore, we performed a case control study to assess: (1) If PFLCP offers better functional results and fewer complications than dynamic hip screws (DHS)? (2) Which kind of extracapsular femoral fractures would benefit from PFLCP fixation?

Hypothesis: The PFLCP fixation offers better functional results and fewer complications than the DHS for the treatment of extracapsular fractures.

Patients and methods: A total of 83 patients with extracapsular femoral fractures were recruited. Forty-one patients underwent PFLCP fixation, and 42 patients underwent DHS fixation. Patient information, operative time, blood loss, functional level (as assessed by Sanders' traumatic hip rating scale), bone union, and implant complications were compared for the two treatment groups.

Results: Patients with stable intertrochanteric fractures who underwent PFLCP fixation demonstrated shorter bone union time than the DHS fixation group (3.3 ± 0.2 vs. 4.3 ± 0.1 month; $P < 0.0001$); however, both groups had 100% bone union and good to excellent scores on Sanders' traumatic hip rating scale ($P = 1.000$). Patients with unstable intertrochanteric fractures who underwent PFLCP fixation experienced greater blood loss (619.0 ± 23.9 vs. 474.1 ± 19.8 ml; $P < 0.0001$), which was mainly due to the need for open reduction (64.3% vs. 12.5% ; $P = 0.003$), compared to the DHS fixation group. No differences were identified with respect to bony union, functional level, or complications. Patients with subtrochanteric fractures who underwent PFLCP fixation demonstrated significantly shorter operative times (82.1 ± 4.3 vs. 102.2 ± 2.2 minutes; $P < 0.0001$), less blood loss (751.8 ± 25.4 vs. 987.6 ± 32.0 ml; $P < 0.0001$), shorter bone union times (5.2 ± 0.4 vs. 8.8 ± 1.0 month; $P = 0.006$), more good to excellent Sanders' traumatic hip rating scale scores (92.9% vs. 55.5% ; $P = 0.009$), and fewer complications (14.2% vs. 66.6% ; $P = 0.005$) than the DHS fixation group.

Conclusion: PFLCP fixation offers better functional outcomes and fewer complications for subtrochanteric femoral fractures but not for intertrochanteric femoral fractures.

Levels of evidence: Case control study, level III.

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1. Introduction

Dynamic hip screws (DHS) have been considered as the standard fixation for extracapsular femoral fracture [1] and yielded good results in the patients with stable intertrochanteric fractures [2]. However, its value for comminuted and highly unstable intertrochanteric and subtrochanteric fractures remains uncertain.

High failure rate and excessive impaction have been reported [3–5]. In addition, the long incision required for the DHS fixation can lead to significant blood loss and soft-tissue damage, which may worsen existing comorbidities in elderly patients [6].

Proximal femoral locking compression plate (PFLCP) has been developed recently, which merges locking screw technology with conventional plating techniques. Theoretically, this technique could offer optimum fixation of comminuted and highly unstable fractures that are associated with more shearing and pull-out forces [7–9]. Several studies have reported success with PFLCP fixation for the treatment of complex femoral fractures and for revision operations after the failure of other implants [10–14]. Only one small study compared PFLCP and DHS fixation techniques and showed

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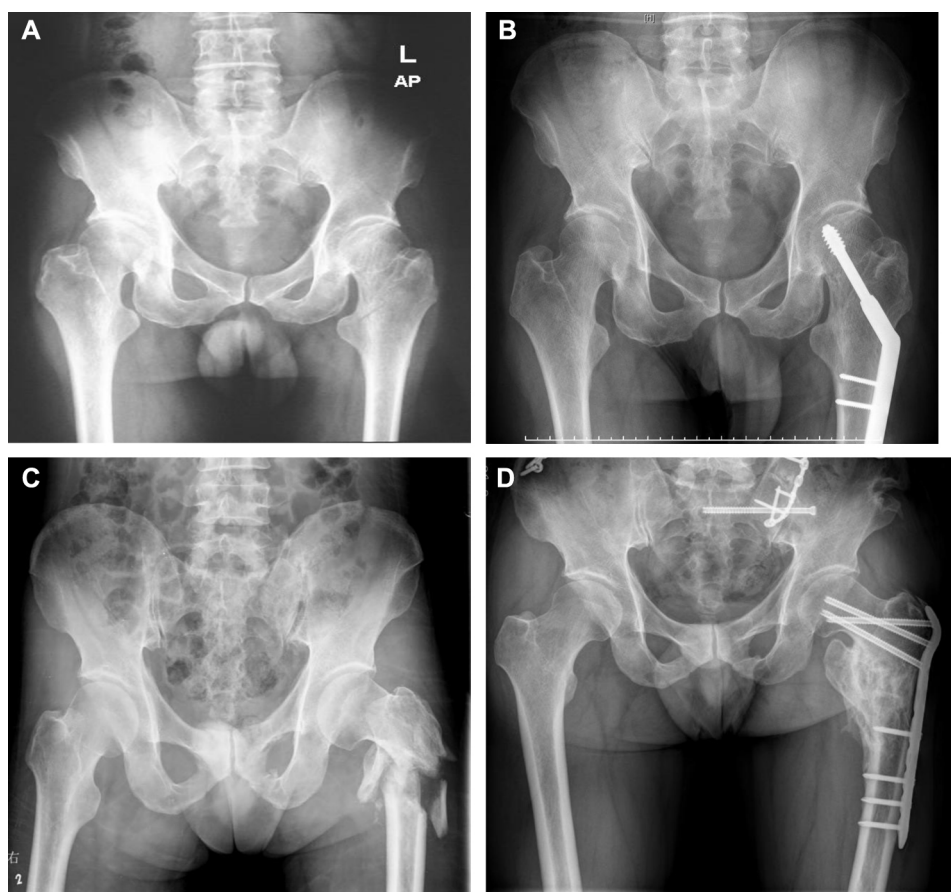


Fig. 1. Fixation of intertrochanteric femoral fracture using dynamic hip screw (DHS) (A, preoperative; B, at union), and unstable subtrochanteric fracture using proximal femoral locking compression plate (PFLCP) (C, preoperative; D, at union).

better bone union with the PFLCP fixation in patients with unstable intertrochanteric fracture [15]. However, whether PFLCP is better than other fixation methods remains obscure. Therefore we performed a case control study to assess:

- Does the PFLCP offer better outcomes (function, bone union rate) and fewer complications than the DHS when dealing with intertrochanteric and subtrochanteric fractures?
- Which type of fractures will be more suitable for the PFLCP fixation?

2. Patients and methods

2.1. Patients

Between September 2009 and January 2011, 136 patients with extracapsular femoral fractures underwent fixation with either DHS or PFLCP (Libeier, Beijing, China) in our department. The choice of fixation technique depended upon availability of the device and each patient's financial situation. Because the cost was 10,000 Yuan for DHS device and 18,000 to 22,000 Yuan for PFLCP device, most patients from rural areas selected DHS fixation. All the procedures were performed by same surgeons. Inclusion criteria were age ≥ 18 years; fractures classified as AO/OTA 31.A1–3 and 32 A3.1, B3.1, and C1.1 on the Osteosynthesefragen/Orthopaedic Trauma Association classification [16]; complete 12-month follow-up. Exclusion criteria included femoral neck fracture; open fracture; pathological fractures due to cancer, infection, inherited bone disorders, or a bone cyst; previous femoral fracture; and contraindications to surgery.

The study was approved by the local hospital ethic committee. Because of the retrospective nature of this study, the requirement of informed patient consent was waived.

2.2. Surgical procedures

Fracture reduction and fixation were carried out in the supine position. Under general anesthesia, closed reduction was obtained using a traction table. Open reduction was performed when necessary (a total of 30 were done mostly in instable fractures, 12 in the DHS group and 28 in PFLCP). PFLCP fixation was described in a previous report [11]. Briefly, a longitudinal incision (about 6.0 cm) of the iliotibial band was made low along the great trochanter. The plate was slid distally in the submuscular plane using a distal counter incision (about 4.0 cm) at the level of the tip of the plate. Three locking neck screws were inserted at 95° and 135° following a guide wire. Four locking screws were then inserted into the shaft. The plate was distally fixed with three to four additional bicortical locking screws. In the case of subtrochanteric comminution, the number of combi holes was 8 to 10 and at least two or three holes of the plate were left empty at the level of the fracture (Fig. 1). The wound was then closed in layers over a negative suction drain. DHS fixation was performed using conventional techniques that have been previously described [17]. Four cortical screws were used for intertrochanteric fractures, and 8 to 10 cortical screws were used for subtrochanteric fractures (Fig. 1).

Partial weight-bearing was allowed after surgery. Full weight-bearing was allowed 6 weeks after surgery in cases of stable intertrochanteric fractures (AO/OTA 31.A1), and permitted only when patients have no pain and bone union was confirmed by X-ray

in cases of unstable intertrochanteric and subtrochanteric fractures (AO/OTA 31.A2-3 and 32 A3.1, B3.1, C1.1). Patients were seen postoperatively at 6 weeks, 3 months, 6 months, and 12 months. Anteroposterior (AP) and lateral radiographs were performed at each follow-up visit.

2.3. Data collection

The following data were collected: patient's demographic information, medical history, causes and AO/OTA classification of each fracture, operation time, blood loss, fracture union, the time to union, osteosynthesis complications, wound infection, deep vein thrombosis, pulmonary embolism, cardiovascular events, and death. Blood loss was calculated as previous report [18], using the formula: $Hgb_{loss} = \text{blood volume} \times (Hgb_{admission} - Hgb_{final}) + Hg_{transfusion}^2$, Blood loss (ml) = $(Hgb_{loss}/Hgb_{admission}) \times 1000^2$. Bone union was defined if AP and lateral X-ray showed lamellar bone formation within 6 month after fixation. Delayed union was defined if bone union occurred 6 to 9 months after fixation. Nonunion was defined if patients had consistent pain and bone union occurred > 12 months after fixation. Nonunion was defined if patients had consistent pain and bone union did not occur 12 months after fixation. When completing 12-month follow-up, functional level was evaluated using traumatic hip rating system proposed by Sanders and Regazzoni [19]. A score of 55–60 is excellent, 45–54 is good, 35–44 is poor, and less than 35 is failure.

2.4. Statistical analysis

Statistical analysis was performed using SPSS 17.0 statistics software (SPSS Inc, Chicago, IL, USA). Variables were presented as mean \pm SE or n (%) and compared with student t -test or Chi². A value of $P < 0.05$ was considered statistically significant.

3. Results

A total of 83 patients were included in the study (41 underwent PFLCP fixation and 42 underwent DHS fixation). No significant differences were identified between groups with respect to age, gender, comorbidities, fracture classification, or preoperative medical treatment (Table 1). The clinical and radiologic outcomes were compared between PFLCP and DHS fixation in patients with stable intertrochanteric fracture (AO/OTA classification 31-A1), unstable

intertrochanteric fracture (AO/OTA classification 31-A2-3), and subtrochanteric fracture (AO/OTA classification 32-A-C).

In the patients with stable intertrochanteric fracture, bone union time was significantly shorter in the PFLCP group compared with the DHS group ($P < 0.0001$); however, both groups had 100% bone union and good to excellent Sanders and Regazzoni traumatic hip rating score ($P = 1.000$). No significant differences were identified for blood loss, hospital stay, and complications between the two groups (all $P > 0.05$) (Table 2).

In the patients with unstable intertrochanteric fracture (Table 3), females accounted for > 70%. The mean age was 64 ± 3 years. Compared with the DHS group, the PFLCP group experienced significantly more blood loss ($P < 0.0001$), which may be due to more cases requiring open reduction ($P = 0.003$). No significant differences were found in Sanders and Regazzoni traumatic hip rating scores, bony union, complications, or length of hospital stay between the two groups.

In the patients with subtrochanteric fractures (Table 4), the main cause was traffic injuries. The mean age was 52 ± 3 years (younger than the patients with intertrochanteric fractures). Compared with the DHS group, the PFLCP group had significantly less operation time, blood loss, bone union time, higher good to excellent functional level, and fewer osteosynthesis complications (all $P < 0.009$).

There were 5 cases of wound infection (2 with PFLCP fixation and 3 with DHS fixation), which were controlled by debridement and dressing. No patient in the entire study experienced deep vein thrombosis, pulmonary embolism, cardiovascular or renal events, or death.

4. Discussion

Theoretically, minimally-invasive PFLCP systems could offer optimum fixation, especially for comminuted and highly unstable fractures, but they have not been extensively studied. In the present study, we compared PFLCP and DHS fixations for the treatment of intertrochanteric and subtrochanteric fractures. Our results suggested that PFLCP fixation was better than DHS fixation when dealing with subtrochanteric fracture, as indicated by significantly shorter operative times, less blood loss, shorter bone union times, higher excellent to good functional level assessed by Sanders and Regazzoni traumatic hip rating scale, and fewer complications. However, no difference was found in patients with intertrochanteric fractures.

Table 1
Demographic and clinical information.

Variables	PFLCP group($n = 41$)	DHS group($n = 42$)	P-value	Total
Age, year	63 ± 2	58 ± 2	0.142	60 ± 14
Sex, male (%)	19 (46.3%)	17 (40.5%)	0.660	36 (43.4%)
Comorbidities				
Hypertension	10 (24.4%)	8 (19.0%)	0.603	18 (21.7%)
Diabetes	6 (14.6%)	7 (16.7%)	1.000	13 (15.7%)
Coronary artery disease	9 (22.0%)	11 (26.2%)	0.798	20 (24.1%)
Renal disease	1 (2.4%)	2 (4.8%)	1.000	3 (3.6%)
Osteoporosis	3 (7.3%)	2 (4.8%)	0.676	5 (6.0%)
Parkinson's disease	3 (7.3%)	2 (4.8%)	0.676	5 (6.0%)
Cause of fracture				
Slip and fall	20 (48.8%)	19 (45.2%)	0.827	39 (47.0%)
Traffic injury	11 (26.8%)	15 (35.7%)	0.479	26 (31.3%)
Fall from height	10 (24.4%)	8 (19.1%)	0.603	18 (33.7%)
Intertrochanteric fracture				
Stable (AO/OTA 31-A1)	13 (31.7%)	8 (19.0%)	0.214	21 (25.3%)
Unstable (AO/OTA 31-A2-3)	14 (34.1%)	16 (38.1%)	0.820	30 (36.1%)
Subtrochanteric fracture				
Stable (AO/OTA 32-A3.1)	14 (34.1%)	18 (42.9%)	0.278	32 (38.6%)
Unstable (AO/OTA 32-B3.1 and C1.1)	6 (14.6%)	4 (9.5%)	0.519	10 (12.0%)
	8 (19.5%)	14 (33.3%)	0.214	22 (26.5%)

PFLCP: proximal femoral locking compression plate; DHS: dynamic hip screw.

Table 2

The perioperative information and postoperative outcomes of PFLCP and DHS fixation for stable intertrochanteric fractures.

Variables	PFLCP group (n = 13)	DHS group (n = 8)	P-value
Age, year	70 ± 3	74 ± 2	0.142
Sex, male (%)	8 (61.6%)	4 (50%)	0.673
Cause of fracture			0.311
Slip and fall	7 (53.8%)	7 (87.5%)	
Traffic injury	2 (15.4%)	0	
Fall from height	4 (30.8%)	1 (12.5%)	
Open reduction	3 (23.1%)	0	0.257
Operative time (minute)	52.5 ± 3.7	50.0 ± 3.0	0.611
Blood loss (ml)	583.3 ± 36.0	563.6 ± 29.2	0.706
Bone union time (month)	3.3 ± 0.2	4.3 ± 0.1	0.000
Length of hospital stay (day)	7.0 ± 0.5	6.9 ± 0.4	0.908
Follow-up (month)	17.7 ± 0.6	18.3 ± 0.3	0.487
Bone union	13 (100%)	8 (100%)	1.000
Functional level assessed by Sanders and Regazzoni [19] traumatic hip rating scale			0.920
Excellent	10 (76.9%)	6 (75.0%)	
Good	3 (23.1%)	2 (25.0%)	
Poor	0	0	
Failure	0	0	
Wound infection	1 (7.7%)	0	0.421

PFLCP: proximal femoral locking compression plate; DHS: dynamic hip screw. P values in bold characters indicate significant differences.

Table 3

The perioperative and postoperative outcomes of PFLCP and DHS fixation for unstable intertrochanteric fractures.

Variables	PFLCP group (n = 14)	DHS group (n = 16)	P-value
Age, year	67 ± 2	64 ± 3	0.498
Sex, male (%)	4 (28.6%)	5 (31.3%)	0.873
Cause of fracture			0.498
Slip and fall	9 (64.3%)	11 (68.8%)	
Traffic injury	2 (14.3%)	4 (25.0%)	
Fall from height	3 (21.4%)	1 (6.2%)	
AO/OTA classification			0.442
31-A.2	8 (57.1%)	12 (75.0%)	
31-A.3	6 (42.9%)	4 (25.0%)	
Open reduction	9 (64.3%)	2 (12.5%)	0.003
Operative time (minute)	55.7 ± 3.0	60.0 ± 3.3	0.347
Blood loss (ml)	619.0 ± 23.9	474.1 ± 19.8	0.000
Bone union time (month)	4.7 ± 0.2	5.5 ± 0.9	0.438
Length of hospital stay (day)	6.6 ± 0.4	6.6 ± 0.3	0.881
Follow-up (month)	20.0 ± 1.0	19.1 ± 0.8	0.480
Functional level assessed by Sanders and Regazzoni [19] traumatic hip rating scale			0.964
Excellent	5 (35.7%)	5 (31.3%)	
Good	6 (42.9%)	7 (43.8%)	
Poor	1 (7.1%)	2 (12.5%)	
Failure	2 (14.2%)	2 (12.5%)	
Complications			
Nonunion	4 (28.6%)	5 (31.3%)	0.596
Deformities	5 (35.7%)	5 (31.3%)	0.796
Screw migration	0	2 (12.5%)	0.341
Screw cut-out	0	1 (6.3%)	0.421
Plate breakage	3 (21.4%)	3 (18.9%)	0.855
Wound infection	0	1 (6.3%)	0.421

PFLCP: proximal femoral locking compression plate; DHS: dynamic hip screw. P values in bold characters indicate significant differences.

The present study has several limitations. First, due to the nature of the retrospective study, clinical heterogeneity may have occurred as a result of preexisting medical conditions such as osteoporosis, fixation usage and individual fracture types. However, these differences were not statistically significant and the two groups were matched for age, sex, and comorbidities. Second, the method of fixation was chosen by patients, which resulted in an unequal distribution of fracture types in each group. Again, these differences were not statistically significant. In fact, this reflects the true conditions of medical practice in China. Finally, the relatively small number of patients restricted statistical power. Big scale, multi-center prospective control studies are warranted.

Nevertheless, our findings still provide useful information for clinical practice.

Similar percutaneous compressing plate systems have been compared with DHS for treatment of intertrochanteric fracture that showed good stability and healing rates [20]. Meta-analysis by Ma et al. [21] also demonstrated the advantages of a similar system with respect to operation time, blood loss and cardiovascular event but not in functional outcome compared with DHS system. In the present study, there were no differences in functional outcomes and complications comparing PFLCP and DHS fixations in patients with intertrochanteric fracture. A high rate of bone union and good to excellent functional level as well as a lower cost and simple

Table 4

The perioperative and postoperative outcomes of PFLCP and DHS fixation for subtrochanteric fractures.

Variables	PFLCP group (n = 14)	DHS group 6 (n = 18)	P-value
Age, year	52 ± 3	46 ± 2	0.092
Sex, male (%)	7 (50.0%)	10 (55.6%)	0.755
Cause of fracture			0.233
Slip and fall	4 (28.6%)	1 (5.6%)	
Traffic injuries	7 (50.0%)	11 (61.1%)	
Fall from height	3 (21.5%)	6 (33.3%)	
AO/OTA classification			0.551
32-A3.1	6 (42.9%)	4 (22.2%)	
32-B3.1	4 (28.6%)	8 (44.4%)	
32-C1.1	4 (28.6%)	6 (33.3%)	
Open reduction	6 (42.9%)	10 (55.5%)	0.771
Operative time (minute)	82.1 ± 4.3	102.2 ± 2.2	0.000
Blood loss (ml)	751.8 ± 25.4	987.6 ± 32.0	0.000
Bone union time (month)	5.2 ± 0.4	8.8 ± 1.0	0.006
Length of hospital stay (day)	6.6 ± 0.3	8.6 ± 0.7	0.055
Follow-up (month)	18.4 ± 0.5	16.9 ± 0.4	0.018
Functional level assessed by Sanders and Regazzoni [19] traumatic hip rating scale			0.009
Excellent	9 (64.3%)	2 (11.1%)	
Good	4 (28.6%)	8 (44.4%)	
Poor	1 (7.1%)	6 (33.3%)	
Failure	0	2 (11.1%)	
Complications			0.005
Nonunion	1 (7.1%)	6 (33.3%)	0.104
Plate breakage	0	4 (22.2%)	0.059
Wound infection	1 (7.1%)	2 (11.1%)	0.702

PFLCP: proximal femoral locking compression plate; DHS: dynamic hip screw. P values in bold characters indicate significant differences.

technique make the DHS preferable for stable intertrochanteric fracture. This recommendation is consistent with the guideline of National Institute for Health and Care Excellence (NICE) [22]. In unstable intertrochanteric fractures, the PFLCP group had 21% incidence of plate breakage, 29% incidence of nonunion and 36% incidence of deformities. Streubel et al. [23] also reported a high rate of screw 'cut-out' and breakage, screw loosening with varus deformity, and plate fracture. Wirtz et al. [24] indicated that the high failure rate might be due to small size and number of proximal screws and the long lever arm of plate, which cannot guarantee a sufficient contact surface for early partial weight-bearing, leading to cut-out and secondary loss of reduction. Wieser et al. [25] claimed that the weakness of the construct was due to the high concentration of stresses at the junction of the locking compression plate with the proximal locking screws. In addition to these factors, the strength of bone likely plays an important role in bone union. In our series, females > 60 years of age comprised the majority of patients with unstable intertrochanteric fractures. Reduced bone mineral density was likely a key to the high rate of nonunion and other complications in our series. Fixation with intramedullary nail may be the best option for these patients [26]; however, control studies are needed.

Although biomechanical studies have showed advantages of PFLCP in the model of subtrochanteric fracture [21,22], these results have never been confirmed by clinical studies yet. Our findings demonstrated that PFLCP fixation is better than DHS fixation because it provided higher functional level and resulted in fewer complications related to fixation device. Additionally, shorter operation time, less blood loss, and lower incidence of wound infection with PFLCP fixation may also benefit the wound healing.

In conclusion, PFLCP fixation can offer better functional outcomes and fewer complications for subtrochanteric femoral fractures. DHS fixation is preferable for stable intertrochanteric fractures. For unstable intertrochanteric fractures, the value of PFLCP fixation needs to be confirmed by further clinical studies.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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